

CALIBRATION STUDIES AT TXAR

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ABSTRACT

This poster presents some of the results of calibration studies at TXAR. Well over 100 regional and teleseismic events that were located by the USGS were used in this study. A time domain correlation method was used to process the TXAR data and obtain estimates of phase velocity and back azimuth for these events. A magnitude scale and an azimuth correction table was then constructed for TXAR.

Keywords: array, TXAR, phase velocity, back azimuth, calibration, magnitude

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OBJECTIVE:

Provide sufficient calibration information such that TXAR can provide reliable single-array locations and magnitudes of seismic events.

RESEARCH RESULTS:

Calibration is generally required in order to reduce bias in location and magnitude determinations at regional to near-teleseismic distances using seismic array data. Calibration is particularly important at TXAR because the array is located near the boundary between two geophysically different regions, the Mid-continent and the Basin and Range Provinces. A modified version of the correlation method described by Cansi, Plantet and Massinon was used to estimate azimuth and horizontal phase velocity of 36 events recorded at TXAR for which we had USGS m_b values. Modifications to the correlation method include Fourier interpolation of the data by a factor of 8 to obtain a virtual sample rate of 320/sec, use of an L-1 technique (least absolute deviation) to obtain estimates of azimuth and phase velocity, and a moving window display to indicate those portions of the waveform that show strongest correlation across the array.

Figures 1-4 show the estimates of phase velocity and azimuth for the four events. For some azimuths (Oklahoma event) the estimated azimuth is within a couple of degrees of the USGS back azimuth from TXAR, but for other events (Western Texas), the estimated azimuth is off by 16 degrees. This bias in estimated azimuth results from crustal structure under TXAR and must be corrected before making a single array location. Figure 5 shows the azimuth bias more than 100 events. In addition, at some azimuths the first arrivals from regional events had phase velocities normally associated with Pn (less than 8.6 km/sec) but to the northwest beyond about 1600 km the first arrival was always an upper mantle refraction with phase velocity greater than 8.6 km/sec. Phase identification is essential in order to select a suitable magnitude scale.

Array Data Processing Outline

- ❖ Digital array data were loaded.
- ❖ Data from excessively noisy channels were discarded.
- ❖ Data were band-pass filtered between 0.75 and 10 Hz with the exception of two events. (Oklahoma, 1-3 Hz and Wyoming, 0.5 - 5 Hz).
- ❖ A 3.2 second window was selected.
- ❖ Data were Fourier interpolated by a factor of 8 to obtain a virtual sampling rate of 320/sec.
- ❖ A complete correlation matrix was computed.
- ❖ A complete lag matrix was computed by calculating the lag-times of the maxima of the cross-correlation functions. This matrix must be skew-symmetric.
- ❖ The lag matrix was corrected for differences in station elevations within the array.
- ❖ In the absence of noise and computational errors, the lag matrix is Toeplitz.
- ❖ Median values were used to estimate the elements of the Toeplitz matrix.
- ❖ An iterative L-1 method (minimum absolute deviation) was used to estimate azimuth and horizontal phase velocity using the elements of the estimated matrix.
- ❖ The 3.2 second window was advanced 5 data points (125 millisec) and the correlation process repeated.
- ❖ Estimates of phase velocity and azimuth and the normalized sum of the absolute errors of fit were plotted as a function of window start time.
- ❖ A "best" window was selected based on stability of estimates and minimum estimation error.
- ❖ The array beam was computed based on estimates from the "best" window.

Explanation Of Figures

Subplot 1

Shows the filtered beam and the 3.2 seconds window used to estimate azimuth and phase velocity.

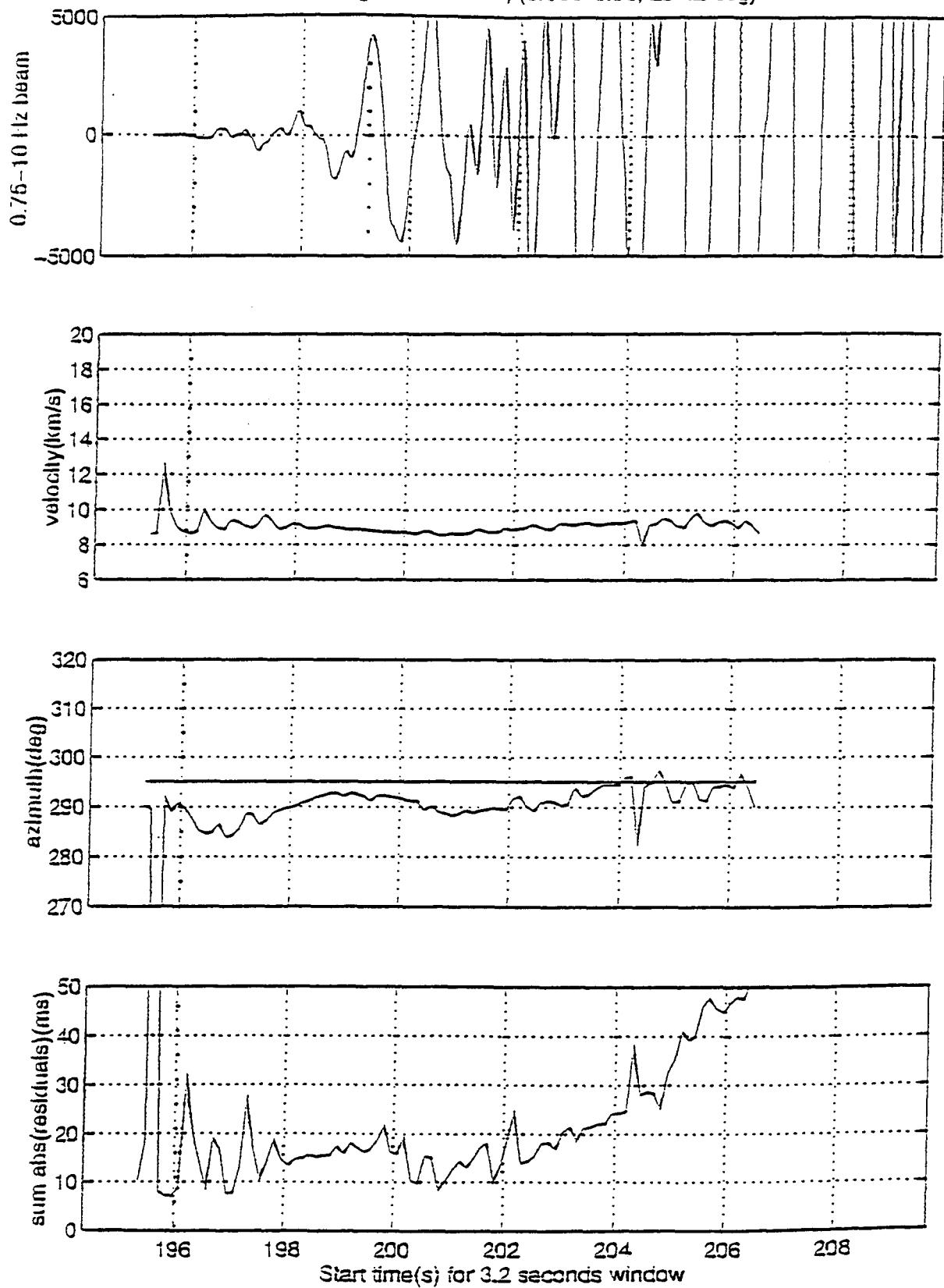
Subplot 2,3

Shows the waveforms parameters, velocity and azimuth, as a function of the start time of successive 3.2 second windows. The dotted line shows the accepted estimates.

Subplot 4

Shows the normalized sum of the time residuals as a function of the start time of the 3.2 second windows.

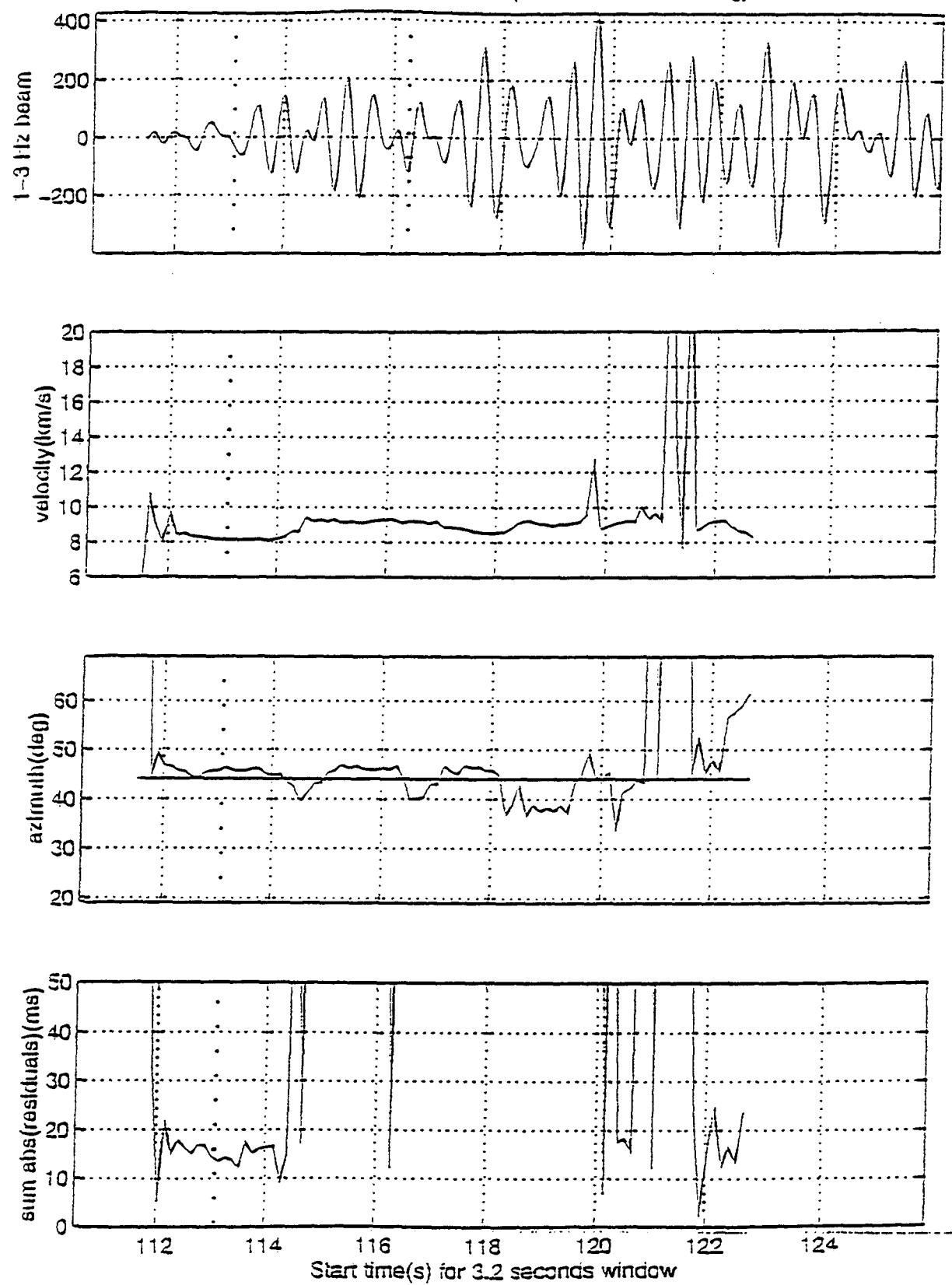
Northridge, 01/17/1994, (8.603 km/s, 291.2 deg)



NORTHRIDGE mb 6.4

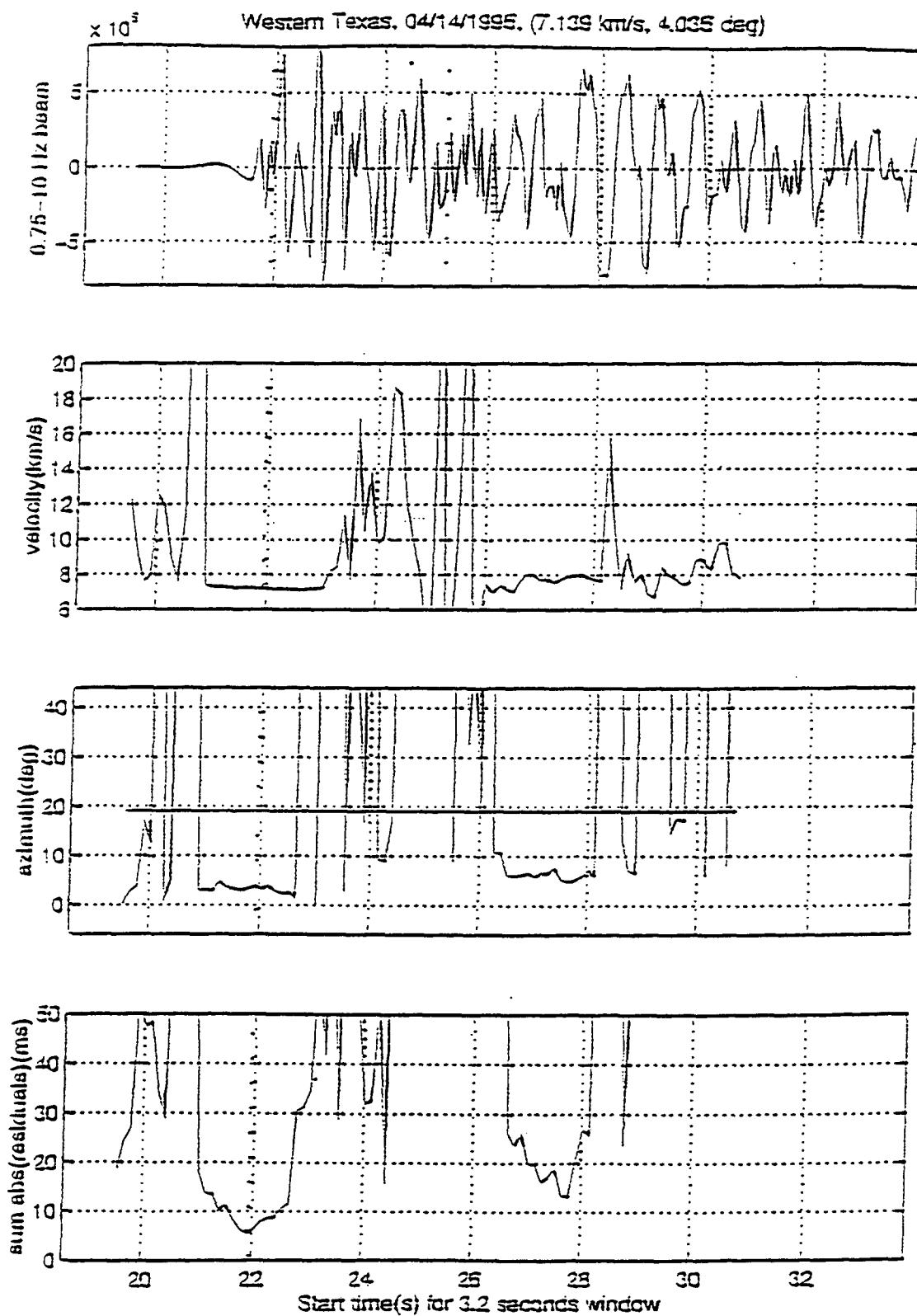
Origin Time: 01/17/94 12:30:55.3
Distance: 1505 km Azimuth: 295°

Oklahoma, 01/18/1995, (8.485 km/s, 44.67 deg)



OKLAHOMA mb 4.0 (mb Lg)

Origin Time: 01/18/95 15:51:37
Distance: 819 km Azimuth: 44°



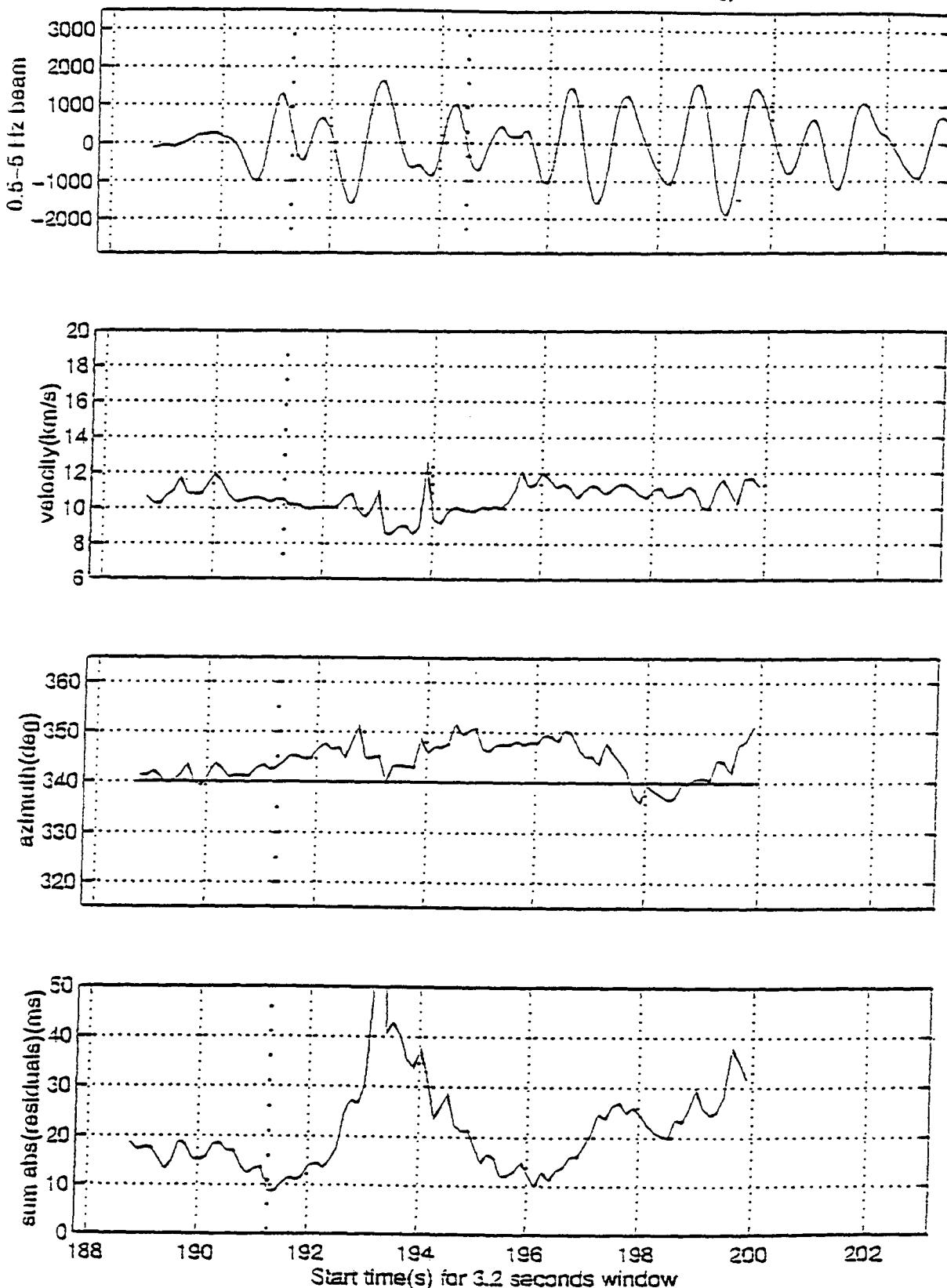
WESTERN TEXAS m_w 5.8

Origin Time: 04/14/95 00:32:54

Distance: 107 km Azimuth: 19°

The correlation method works well with digitally clipped data.

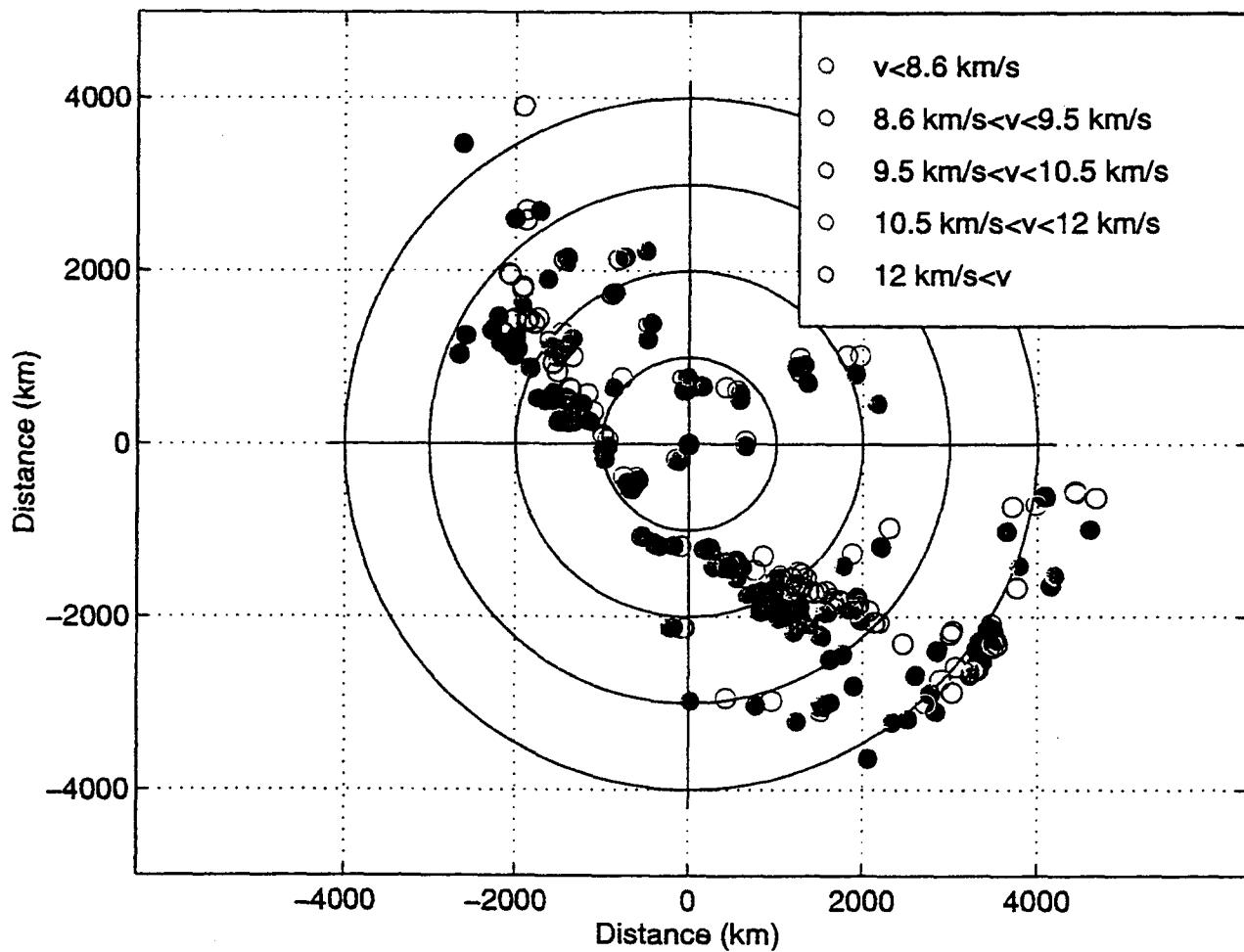
Wyoming, 02/03/1995, (10.5 km/s, 343 deg)



WYOMING mb 5.4

Origin Time: 02/03/95 15:26:11
Distance: 1468 km Azimuth: 340°

Location of the events relative to TXAR



True azimuth (USGS) – open circles
Calculated azimuth (TXAR) – solid circles

(Original in color)

Magnitude Estimation at TXAR

Various magnitude estimates were made for the first 35 events analyzed and compared with USGS m_b . The most reliable estimates were those that used the Denny, Taylor and Vergino formula as follows.

For horizontal phase velocity less than 8.6 km/sec:

$$m_b(D) = \log A + 2.4(\log \Delta) - 3.95 + C$$

with $C=-0.35$

For horizontal phase velocity greater than 8.6 km/sec:

$$m_b(D) = \log A + 2.4(\log \Delta) - 3.95 + C$$

with $C=-0.05$

where A is zero to peak amplitude in nanometers and Δ is epicentral distance in km.

CONCLUSIONS AND RECOMMENDATIONS

We now have adequate calibration data to locate and determine the magnitude of regional events that are not seen at PDAR or any other GSETT 3 primary station, but may be observed at secondary stations such as Tucson and Albuquerque. Studies of these events should allow us to determine the effectiveness of single array detection.